

Claims:

1. An integrated circuit comprising:

a two-dimensional pyramid filter architecture of an order  $2N-1$ , where  $N$  is a positive integer greater than three;

said two dimensional pyramid filter architecture of order  $2N-1$ , in operation, capable of producing, on respective clock cycles, at least the following:

pyramid filtered output signals corresponding to output signals produced by ten one-dimensional pyramid filters of order  $2N-1$ ; and

pyramid filtered output signals corresponding to output signals produced either by four two-dimensional pyramid filters or one two-dimensional pyramid filter of order  $[2(N-1) - 1]$  using signal sample matrices of order  $[2(N-1)-1]$ ;

wherein the respective output signals in said two dimensional pyramid filter architecture are summed on respective clock cycles of said two dimensional pyramid filter architecture.

2. The integrated circuit of claim 1, wherein  $N$  is five; and

wherein said two dimensional pyramid filter architecture of order nine, in operation, capable of producing, on respective clock cycles, the pyramid filtered output signals corresponding to output signals produced either by four two-dimensional pyramid filters or one two-dimensional pyramid of order seven using four signal sample matrices  $P_{i-1,j-1}^{7 \times 7}$ ,  $P_{i-1,j+1}^{7 \times 7}$ ,  $P_{i+1,j-1}^{7 \times 7}$ ,  $P_{i+1,j+1}^{7 \times 7}$ , the pyramid filtered output signals being produced by a plurality of one-dimensional pyramid filters.

3. The integrated circuit of claim 2, wherein said one-dimensional pyramid filters comprise a sequence of scalable cascaded multiplierless operational units, each of said operational units capable of producing a different order pyramid filtered output signal sample stream.

4. The integrated circuit of claim 2, wherein said one-dimensional pyramid filters comprise other than one-dimensional multiplierless pyramid filters.

5. The integrated circuit of claim 2, wherein said two dimensional pyramid filter architecture of order nine, in operation, capable of producing, on respective clock cycles, the pyramid filtered output signals

corresponding to output signals produced either by four two-dimensional pyramid filters or one two-dimensional pyramid of order seven using four signal sample matrices  $P_{i-1,j-1}^{7 \times 7}$ ,  $P_{i-1,j+1}^{7 \times 7}$ ,  $P_{i+1,j-1}^{7 \times 7}$ ,  $P_{i+1,j+1}^{7 \times 7}$ , the pyramid filtered output signals produced by a plurality of one-dimensional pyramid filters being produced by eight one-dimensional pyramid filters of order seven.

6. The integrated circuit of claim 5, wherein, of the eight one-dimensional pyramid filters of order seven, four are applied row-wise and four are applied column-wise.

7. The integrated circuit of claim 5, wherein said two dimensional pyramid filter architecture of order nine, in operation, capable of producing, on respective clock cycles, the pyramid filtered output signals corresponding to output signals produced by four two-dimensional pyramid filters of order seven, the pyramid filtered output signals produced by a plurality of one-dimensional pyramid filters being produced by eight one-dimensional multiplierless pyramid filters of order seven.

8. The integrated circuit of claim 7, wherein, of the eight one-dimensional pyramid filters of order seven, four are applied row-wise and

four are applied column-wise.

9. The integrated circuit of claim 2, wherein said two dimensional pyramid filter architecture of order nine, in operation, capable of producing, on respective clock cycles, the pyramid filtered output signals corresponding to output signals produced by four two-dimensional pyramid filters of order seven, the pyramid filtered output signals produced by a plurality of one-dimensional pyramid filters being produced by other than one-dimensional multiplierless pyramid filters.

10. The integrated circuit of claim 1, wherein N is five;  
said two dimensional pyramid filter architecture of order nine, in operation, being capable of producing, on respective clock cycles, at least the following:

output signals produced by four two-dimensional pyramid filters of order seven.

11. The integrated circuit of claim 1, wherein said two dimensional pyramid filter architecture of order nine, in operation, capable of producing, on respective clock cycles, the pyramid filtered output signals

corresponding to output signals produced by four two-dimensional pyramid filters of order seven, the pyramid filtered output signals being produced by one or more two-dimensional pyramid filters other than four two-dimensional pyramid filters.

12. A method of filtering an image using a two-dimensional pyramid filter architecture of order  $2N-1$ , where  $N$  is a positive integer greater than four, said method comprising:

summing, on respective clock cycles of said two dimensional pyramid filter architecture, the following:

pyramid filtered output signals corresponding to output signals produced by ten one-dimensional pyramid filters of order  $2N-1$ ; and

pyramid filtered output signals corresponding to output signals produced either by four two-dimensional pyramid filters or one two-dimensional pyramid filter of order  $[2(N-1) - 1]$  using signal sample matrices of order  $[2(N-1)-1]$ .

13. The method of claim 12, wherein  $N$  is five;

pyramid filtered output signals corresponding to output signals produced either by four two-dimensional pyramid filters or one two-

dimensional pyramid filter of order  $[2(N-1) - 1]$  using signal sample matrices of order  $[2(N-1)-1]$  comprising output signals produced by four two-dimensional pyramid filters of order seven.

14. The method of claim 12, wherein N is five; and

wherein the pyramid filtered output signals corresponding to output signals produced either by four two-dimensional pyramid filters or one two-dimensional pyramid filter of order seven using four signal sample matrices  $P_{i-1,j-1}^{7 \times 7}, P_{i-1,j+1}^{7 \times 7}, P_{i+1,j-1}^{7 \times 7}, P_{i+1,j+1}^{7 \times 7}$  comprise pyramid filtered output signals produced by a plurality of one-dimensional pyramid filters.

15. The method of claim 14, wherein said one-dimensional pyramid filters comprise a sequence of scalable cascaded multiplierless operational units, each of said operational units capable of producing a different order pyramid filtered output signal sample stream.

16. An article comprising: a storage medium, said storage medium having stored thereon instructions, that, when executed result in filtering an image using a two-dimensional pyramid filter architecture of order  $2N-1$ , where N is a positive integer greater than four, by:

summing, on respective clock cycles of said two dimensional pyramid filter architecture, the following:

pyramid filtered output signals corresponding to output signals produced by ten one-dimensional pyramid filters of order  $2N-1$ ; and

pyramid filtered output signals corresponding to output signals produced either by four two-dimensional pyramid filters or one two-dimensional pyramid filter of order  $[2(N-1) - 1]$  using signal sample matrices of order  $[2(N-1)-1]$ .

17. The article of claim 16, wherein  $N$  is five;

pyramid filtered output signals corresponding to output signals produced either by four two-dimensional pyramid filters or one two-dimensional pyramid filter of order  $[2(N-1) - 1]$  using signal sample matrices of order  $[2(N-1)-1]$  comprising output signals produced by four two-dimensional pyramid filters of order seven.

18. The article of claim 16, wherein  $N$  is five; and

wherein the pyramid filtered output signals corresponding to output signals produced either by four two-dimensional pyramid filters or one two-dimensional pyramid of order seven using four signal sample

matrices  $P_{i-1,j-1}^{7 \times 7}, P_{i-1,j+1}^{7 \times 7}, P_{i+1,j-1}^{7 \times 7}, P_{i+1,j+1}^{7 \times 7}$ , comprise pyramid filtered output signals produced by a plurality of one-dimensional pyramid filters.

19. The article of claim 18, wherein said one-dimensional pyramid filters comprise a sequence of scalable cascaded multiplierless operational units, each of said operational units capable of producing a different order pyramid filtered output signal sample stream.

20. An image processing system comprising:  
 an image processing unit to filter scanned color images;  
 said image processing unit including at least one two-dimensional pyramid filter architecture;  
 said at least one two-dimensional pyramid filter architecture comprising:  
 a two-dimensional pyramid filter architecture of an order  $2N-1$ , where  $N$  is a positive integer greater than four;  
 said two dimensional pyramid filter architecture of order  $2N-1$ , in operation, capable of producing, on respective clock cycles, at least the following:  
 pyramid filtered output signals corresponding to output signals



produced by ten one-dimensional pyramid filters of order  $2N-1$ ; and  
 pyramid filtered output signals corresponding to output signals  
 produced either by four two-dimensional pyramid filters or one two-  
 dimensional pyramid filter of order  $[2(N-1) - 1]$  using signal sample  
 matrices of order  $[2(N-1)-1]$ ;

wherein the respective output signals in said two dimensional  
 pyramid filter architecture are summed on respective clock cycles of said  
 two dimensional pyramid filter architecture.

21. The system of claim 20, wherein  $N$  is five;

pyramid filtered output signals corresponding to output signals  
 produced either by four two-dimensional pyramid filters or one two-  
 dimensional pyramid filter of order  $[2(N-1) - 1]$  using signal sample  
 matrices of order  $[2(N-1)-1]$  comprising output signals produced by four  
 two-dimensional pyramid filters of order seven.

22. The system of claim 20, wherein  $N$  is five; and

wherein the pyramid filtered output signals corresponding to output  
 signals produced either by four two-dimensional pyramid filters or one two-  
 dimensional pyramid of order seven using four signal sample

matrices  $P_{l-1,j-1}^{7 \times 7}, P_{l-1,j+1}^{7 \times 7}, P_{l+1,j-1}^{7 \times 7}, P_{l+1,j+1}^{7 \times 7}$ , comprise pyramid filtered output signals produced by a plurality of one-dimensional pyramid filters.

23. The system of claim 22, wherein said one-dimensional pyramid filters comprise a sequence of scalable cascaded multiplierless operational units, each of said operational units capable of producing a different order pyramid filtered output signal sample stream.